



SECTION I GENERAL INFORMATION

1.1 INTRODUCTION AND DESCRIPTION

This manual describes the performance and operating features of Models 220 and 225 Digital Phase Angle Voltmeters (DPAV) together with information on calibration, maintenance, general troubleshooting and parts listing.

The primary function of the Phase Angle Voltmeter is to make the following measurements on an AC voltage:

1. TOTAL: Average of the rectified signal, including noise and harmonics (scaled in RMS).
2. FUNDamental: Fundamental voltage
3. IN-PHASE: Rectangular (vector) component of input voltage in phase with a reference input voltage of the same frequency. Polarity and magnitude of voltage is displayed.
4. QUADrature: Rectangular component of input voltage 90° out of phase with an input reference voltage. Polarity and magnitude of voltage is displayed.
5. PHASE ANGLE: The amount of phase shift in degrees by which the signal voltage leads the reference. The range is +0.0° to +359.9°.

In all measurement modes, except TOTAL, effects of noise and harmonics are rejected by an amount defined in the specifications.

A detailed breakdown of the features and options of Models 220 and 225 is provided in paragraph 1.3. The basic 220 is configured as a single frequency phase-sensitive voltmeter capable of measuring the FUNDamental, IN-PHASE and QUADrature voltages of the pre-selected frequency, plus broadband TOTAL mode measurements. The full complement of options can then be added as desired to satisfy individual requirements.

The Model 225 is a multi-frequency instrument with the PHASE ANGLE, REF PHASE and AUTORANGING options as standard, making it more suitable for broad general purpose applications.



In both models of the Digital Phase Angle Voltmeter, phase angle is measured by a unique (patent pending) type of signal processing designated the $\text{TAN}^{-1}\text{GO}^{\text{TM}}$ angle computation. Key features and options of the instruments are:

1. 10mV to 500V scaling (see specifications for maximum input)
2. Signal autoranging
3. 4-1/2 digit display
4. Reference Level automatic gain control
5. OVERLOAD and NO SYNC warning lights
6. 20% over-ranging
7. $\pm 45^\circ$ REFERENCE OFFSET adjustment
8. REMOTE CONTROL and DATA OUTPUT
9. REFERENCE and SIGNAL isolation
10. 30Hz to 32kHz phase-sensitive frequency range
11. DC Recorder Output

The seven segment, 1/2" high, planar Beckman Display provides an easy to read, wide viewing angle readout. Range, function and warning lights are also displayed.

The general packaging approach is planar with most circuitry on large horizontal boards. This allows for ease of maintenance and troubleshooting.

1.2 SPECIFICATIONS

The following specifications apply to North Atlantic Industries' Models 220 and 225. Where a special modification or variation is involved, the governing specifications will be either a separate specification control document, the purchase order or a supplement contained in this manual. The options contained in an instrument are identified on the rear panel nameplate. The option numbers are in paragraph 1.3.



- 1.2.1 SIGNAL VOLTAGE RANGE: 10mV to 1000V rms in 6 ranges. 120% over-range.
- 1.2.2 MAXIMUM SIGNAL INPUT: 500V rms (± 400 VDC max.) for non-isolated, Broadband Isolation (Option 05) and DIRECT mode in Transformer Isolation (Option 04).
- Determined by "F" rating in Transformer Isolation (Option 04). $0.75F$ at 400Hz where F = frequency in Hz. 0VDC without external coupling capacitor.
- 1.2.3 REFERENCE VOLTAGE RANGE: 0.2V to 200V rms, AGC (no adjust necessary) (± 50 VDC max.)
- 1.2.4 SIGNAL AUTORANGING: Up-ranges at 120% of range. Down-ranges at 10% of range. 330 milliseconds per range change.
- 1.2.5 DISPLAY: Beckman Information Display, 0.55" high indicates polarity and digital reading. Illuminated window indicates unit of measurement, mode overload and no sync condition.

Voltage: 4-1/2 digits, 0.01% full range resolution

Phase: $+0.0^\circ$ to $+359.9^\circ$ phase lead. 0.1° resolution.

- 1.2.6 FREQUENCY RANGE: TOTAL MODE: 30Hz to 100kHz
- FUNDamental, IN PHASE, QUAD and ANGLE Modes: 1, 2, 3 or 4 frequencies from 30Hz to 32kHz, $\pm 5\%$ bandwidth.
- 1.2.7 WARM-UP TIME: ~2 hours for rated accuracy.

1.3



1.2.8 VOLTAGE ACCURACY:**

1.2.8.1 TOTAL Mode (Non-Isolated Mode)

Accuracy(23°C±5°C) Temp. Coef. (0-18°C, 28-50°C)

60Hz to 30kHz	0.25% FS	0.01%/°C
30Hz to 100kHz	0.5% FS	0.02%/°C

TOTAL MODE Accuracy (Isolated Mode Only)

Accuracy(23°C±5°C) Temp. Coef. (0-18°C, 28-50°C)

60Hz to 10kHz	±.25% FS	0.01%/°C
30Hz to 30kHz	±.5% FS	0.02%/°C
30kHz to 100kHz	±1% FS	0.04%/°C

1.2.8.2 FUND & PHASE SENSITIVE Modes

Accuracy(23°C±5°C) Temp. Coef. (0-18°C, 28-50°C)

30Hz to 60Hz	0.05% FS +0.1% rdg.	(.003% FS +0.01% rdg)/°C
60Hz to 1.5kHz	0.05% FS +0.07% rdg.	(.003% FS +0.005% rdg)/°C
1.5kHz to 20kHz	0.1% FS +0.15% rdg.	(.004% FS +0.012% rdg)/°C
20kHz to 32kHz	0.15% FS +0.2% rdg.	(.005% FS +0.016% rdg)/°C

1.2.9 PHASE ACCURACY (PHASE ANGLE & REF PHASE MODES)

(Accuracy-23°C±5°C)

Arc

Temp. Coef.

Display

Tangent*

(0-18°C, 28-50°C)

30Hz to 60Hz	0.25° ±1/2LSB	0.2°	.015°/°C
60Hz to 5kHz	0.2° ±1/2LSB	0.13°	.01°/°C
5kHz to 20kHz	0.25° ±1/2LSB	0.2°	.015°/°C
20kHz to 32kHz	0.35° ±1/2LSB	0.3°	.02°/°C

* For SIGNAL level above 30% FS

NOTE: For an instrument with the Angle Mode Option (01), without the Autorange Option (02), the accuracy specification increases 50% when the SIGNAL level is between 10% and 30% full scale.

1.2.10 ORTHOGONALITY

(23°C ±5°C)

Temp. Coef. (0-18°C, 28-50°C)

30Hz to 60Hz	0.15°	0.01°/°C
60Hz to 5kHz	0.09°	0.007°/°C
5kHz to 20kHz	0.15°	0.01°/°C
20kHz to 32kHz	0.2°	0.015°/°C

1.2.11 HARMONIC REJECTION

Fundamental & Phase-Sensitive Modes: 2nd and 3rd harmonic is 40db to 70db dependant on frequency. All other harmonics will vary with frequency and harmonic order.

**Noise & Offset

Accuracy at zero input, in the voltage measurement modes, is defined as the ___% FS statement in the various specifications. Total Mode, 10mV range, noise specification is 35uV.



1.2.17.2 Digital Outputs

Low ("0") = 0V to 0.5V, 12mA maximum sink current

High ("1") = +2.4V to +5V, 6kΩ source resistance

1.2.17.3 MODE TRUTH TABLE

	<u>Remote Control (J1)</u>			<u>Digital Output (J2)</u>		
	Pin			Pin		
	5	6	7	37	36	25
TOTAL	0	0	1	0	0	1
FUND	0	1	0	0	1	0
IN-PHASE	0	1	1	0	1	1
QUAD	1	0	0	1	0	0
PHASE ANGLE	1	0	1	1	0	1
	<u>J1 Pin 1</u>			<u>J2 Pin 17</u>		
REF OFFSET	1			1		

1.2.17.4 RANGE TRUTH TABLE

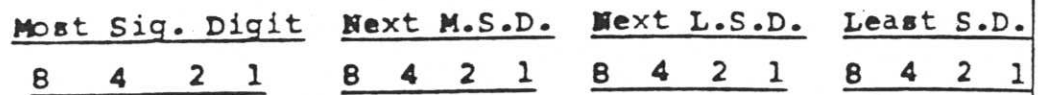
	<u>Remote Control (J1)</u>			<u>Digital Output (J2)</u>		
	Pin			Pin		
	2	3	4	19	18	16
10mV	0	0	0	0	0	0
100mV	0	0	1	0	0	1
1000mV	0	1	1	0	1	1
10V	1	0	0	1	0	0
100V	1	0	1	1	0	1
1000V	1	1	1	1	1	1
Auto	1	1	0			

1.2.17.5 FREQUENCY TRUTH TABLE

	<u>Remote Control (J1)</u>		<u>Digital Output (J2)</u>	
	Pin		Pin	
	8	15	35	34
F1	0	0	0	0
F2	0	1	0	1
F3	1	0	1	0
F4	1	1	1	1

1.2.17.6 DATA OUTPUT (BCD) J2

	<u>Pin 33</u>	<u>Pin 13</u>
Polarity +:	1	Over-range 1: 1
-:	0	



J2 Pin: 12 10 9 8 7 6 5 4 1 2 3 24 23 22 21 20

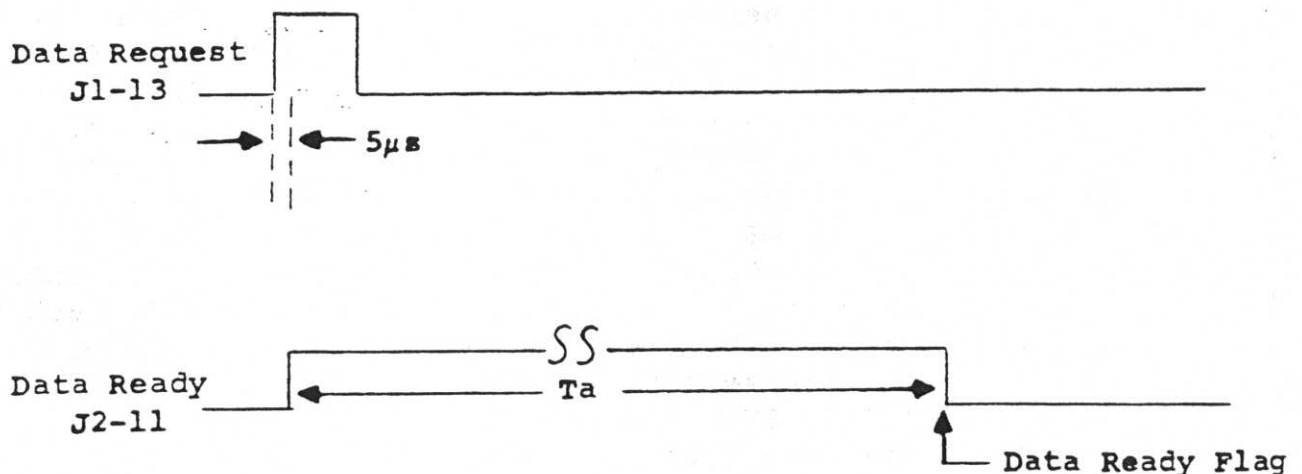
1.2.14.7 OVERLOAD FLAG J2-15
Signal Overloaded: 1 (pulsing)
NO SYNC FLAG J2-14
Out of Sync: 1

1.2.17.8 DATA REQUEST/READY

Data Request Pulse: Logic "1" for from 25 μ s to 1 sec. duration.

Data Ready: Logic "1" pulse whose leading edge trails Data Request leading edge by approximately $5\mu s$; trailing edge to logic "0" is the Data Ready flag. The duration is a function of state of system, i.e., whether it is ranging, overloaded, out of sync.

TIMING DIAGRAM



Where the unit is not ranging, or overloaded or out of sync, T_a is approximately 2.5 seconds.

If, after a Data Request pulse, the unit is ranging, out of sync or overloaded, the Data Ready flag will occur 2.5 seconds after the unit reaches a stable operating condition.

Where the unit is in TOTAL mode and is overloaded after Data Request, the Data Ready flag will occur approximately 6 seconds after unit comes out of overload.



1.2.17.9 CONNECTOR WIRING

Remote Control (J1)

Pin 1	REF OFFSET	Pin 9	Ground
2	} Range Remote Control	10	} Spares
3		11	
4		12	
5	} Mode Remote Control	13	Data Request
6		14	+5V
7		15	FREQ SELECT
8	FREQ SELECT		

Digital Outputs (J2)

Pin 1	"8" of next LSD	Pin 20	"1" of LSD
2	"4" of next LSD	21	"2" of LSD
3	"2" of next LSD	22	"4" of LSD
4	"1" of next MSD	23	"8" of LSD
5	"2" of next MSD	24	"1" of next LSD
6	"4" of next MSD	25	Mode Output
7	"8" of next MSD	26-32	Spares
8	"1" of MSD	33	Polarity
9	"2" of MSD	34	FREQ SELECT Output
10	"4" of MSD	35	FREQ SELECT Output
11	DATA READY	36	Mode Output
12	"8" of MSD	37	Mode Output
13	Over-range Digit		
14	OUT OF SYNC Flag		
15	Overload Flag		
16	Range Output		
17	REF OFFSET		
18	Range Output		
19	Range Output		



1.2.18 DC RECORDER OUTPUTS (OPTION 06)

IN-PHASE and QUADrature DC outputs are available at rear panel. TOTAL and FUNDamental DC voltages appear at IN-PHASE terminals when unit is in appropriate mode. Low terminal is instrument circuit ground.

Full Scale Output: $\pm 8.75V \pm 5\%$

Output Impedance: $2k\Omega$

Linearity and Stability: Same as specification for TOTAL, FUND, IN-PHASE and QUAD modes.

1.2.19 MECHANICAL SPECIFICATIONS

Size:	Panel is 5-7/32" x 19"
	Depth behind panel: 15"
	Width behind panel: 16-3/4"
Weight:	30 lbs. net, 35 lbs. shipping
Mounting:	Rack or bench mounted
Front Panel Paint:	Semi-Gloss Gray #26280 (Dress Panel) #26132 (Sub-Panel)
Line Cord:	6' long with ground pin
Front Panel Input:	Inputs are standard, 5-way binding posts, spaced on 3/4" centers

Specifications subject to change without notice



1.3 OPTIONS AND FEATURES

1.3.1 Tabulation

STANDARD & OPTIONAL FEATURES	MODEL 220	MODEL 225
TOTAL, FUNDAMENTAL, IN-PHASE & QUADRATURE Voltage Modes and Reference Isolation	Included	Included
Phase-Sensitive Frequencies Included	1	2
Optional Frequencies	N/A	3rd or 4th
ANGLE MODE & $\pm 45^\circ$ PHASE OFFSET	Option 01	Included
Auto Ranging	Option 02	Included
Remote Control & Digital Output	Option 03	Option 03
Transformer Isolation (Signal)	Option 04	N/A
Broadband Isolation (Signal)	Option 05	Option 05
DC Recorder Output (VOLTAGE Modes Only)	Option 06	Option 06
Rear Input Connectors (Signal & Reference)	MS Type: Option 07 Terminal Strips: Option 08	Option 07 Option 08
Special Custom Variation (Contact Factory)	Option 09	Option 09
Rack Mount Adapter & Ribbon Cable Removal Tool	Included	Included
Ratio Option	See Section IX	
Null Meter	Option 10	Option 10